Department of Pesticide Regulation

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MEMORANDUM

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DATE: May 26, 1999

SUBJECT: PRELIMINARY RESULTS OF ACUTE AND CHRONIC TOXICITY TESTING OF SURFACE WATER MONITORED IN THE SACRAMENTO RIVER WATERSHED, WINTER 1998-99

SCOPE OF THIS MEMORANDUM

The purpose of this memorandum is to provide results of water sampling conducted on the Sacramento River by the Department of Pesticide Regulation (DPR). Data included here are from the period December 7, 1998 to March 5, 1999 and encompass results from both chemical analyses conducted by the California Department of Food and Agriculture (CDFA) Center for Analytical Chemistry and bioassays conducted by the California Department of Fish and Game (DFG). This memorandum summarizes the third-year of a five-year study, begun in 1996, designed to monitor the occurrence of toxicity and dormant spray insecticides in the Sacramento River watershed. An in-depth interpretation of the data is not included here but will be provided in the final report, which will include data from all five years of the study.

BACKGROUND

The Sacramento River is the largest river in California both in volume of water and in drainage area (Friebel et al., 1995) (Figure 1). From Mount Shasta in the north to the Sacramento-San Joaquin Delta in the south, the river flows for 327 miles and drains approximately 27,000 square miles including agricultural, urban and undeveloped land areas (Domagalski and Brown, 1994). The primary source of water entering the system is surface runoff from the Sierra Nevada Mountains to the east and Cascade Range to the north (CSLC, 1993). Runoff from rain events occurring in the Sacramento Valley and Coastal Range Mountains provide short term increases in river flow. Seasonal rains occur from October to March with little significant rain from June to September. River flow during the summer is composed of dam releases of snow-melt water for agricultural, urban, recreational and wildlife purposes.

In the Sacramento Valley, the organophosphorus insecticides diazinon and methidathion are the primary dormant season insecticides used on stone fruit and nut crops (DPR 1994; DPR 1995; DPR 1996;). This dormant spray application period coincides with the bulk of the seasonal rainfall, providing the potential for these pesticides to wash off target areas and migrate with surface runoff to the Sacramento River. Runoff from orchard areas west of the Sacramento River chiefly flows into the Colusa Basin Drain which enters the Sacramento River at Knights Landing (Figure 2). Runoff from dormant spray areas east of the Sacramento River principally flows into Butte Creek, which has been engineered to drain into the Sutter Bypass via the Butte Slough (Figure 3). Runoff from the west side of the Feather River also drains into the Sutter Bypass. During periods of normal flow, the Sutter Bypass enters the Sacramento River via the Sacramento Slough at Karnak. During periods of high flow, the Sutter Bypass channel fills completely with runoff from this area plus water diverted from the Sacramento River. This flow merges with the Feather River 8 miles prior to entering the Sacramento River, forming a two mile wide channel which inundates the Sacramento Slough. During floods, a large portion of the flows of the Sacramento River and the Sutter Bypass/Feather River will be diverted into the Yolo Bypass. Runoff from areas east of the Feather River drains into the Feather River above Nicolaus.

Previous studies of the Sacramento River by the U.S. Geological Survey (USGS) and DPR have shown that most diazinon detections were observed during the dormant spray season (MacCoy et al., 1995; Ganapathy, 1997). The USGS study also detected low levels of methidathion during this season. In a California Regional Water Quality Control Board (CVRWQCB) study (Foe and Sheipline, 1993), acute toxicity to *Ceriodaphnia dubia* in conjunction with high diazinon and methidathion concentrations was found at Gilsizer Slough, which drains some of the area west of the Feather River and flows into the Sutter Bypass (Figure 2).

During the winters of 1996-97 and 1997-98, DPR conducted monitoring at sites along the Sutter Bypass for acute toxicity and the Sacramento River for chronic toxicity (Nordmark et al., 1998, Nordmark, 1998). Results from the two seasons were similar. No acute toxicity was found at the Sutter Bypass site and no chronic toxicity or reproductive impairment was found at the Sacramento River sites. Diazinon was the primary insecticide detected with most detections occurring in conjunction with rain events.

During the winter of 1996-97, sampling was conducted at two sites, the Sutter Bypass and the Sacramento River at Bryte. Two diazinon pulses were detected in the Sutter Bypass, one in late January and one in late February (Figure 4). The latter pulse lasted up to 2 weeks and did not appear to be related to any storm event. Diazinon was detected in 44% of the samples taken from the Sutter Bypass at levels up to 0.09 μg/L. A single diazinon pulse lasting up to 8 days was detected in the Sacramento River in late-January. Diazinon was detected in 16% of the samples from the Sacramento River at Bryte, with levels as high as 0.07 μg/L. Methidathion was detected in one sample each from the Sutter Bypass and from the Sacramento River. This study was conducted during a dormant season marked by heavy rains and significant flooding during January, which delayed the start of sampling, with virtually no rain after January 29.

During 1997-1998, sampling was conducted at two sites, the Sutter Bypass and the Sacramento River at Alamar Marina. The original Sacramento River site at Bryte was abandoned due to problems with the sampler snagging on underwater obstructions. Inputs between the Alamar and Bryte sites are minimal. Diazinon detections in the Sutter Bypass were sporadic, occurring throughout January and early February (Figure 4). Diazinon was detected in 30% of the Sutter Bypass samples, with a peak concentration of 0.1 µg/L. Two diazinon pulses were observed on the Sacramento River. The first, at the end of January, lasted 3-4 days, the second pulse lasted up to 21 days from early to late February. Diazinon was detected in 40% of the samples collected from the Sacramento River, with levels as high as 0.17 µg/L. Methidathion was detected in a single sample from the Sacramento River. This study was also conducted during a wet dormant season. River and bypass flows were high and rain events occurred regularly until the last week of February.

The objective of this study was to continue monitoring the occurrence of aquatic toxicity, both acute and chronic, in portions of the Sacramento River watershed. Additionally, monitoring was conducted for organophosphate and carbamate insecticides that have historically been applied during the winter months and which have the potential to enter the Sacramento River with surface runoff (Table 1). Results from the previous two years of monitoring showed that, for much of the dormant season, the diversion weirs into the Sutter Bypass were in full operation and pesticide levels at the acute and the chronic sites were roughly equivalent. The water flowing through the Sutter Bypass was largely made up of Sacramento River water which resulted in the acute site not representing a small watershed for most of the dormant season. Therefore, Wadsworth Canal, a tributary of the Sutter Bypass which does not contain major inputs from municipal or industrial sources, was selected for acute toxicity testing to *C. dubia* and chemical analysis. The potential for chronic toxicity was investigated in the Sacramento River at Alamar Marina, which is downstream from dormant spray insecticide inputs into the watershed, yet above input from the American River. Samples were also analyzed for the presence of certain soil applied herbicides which may enter the river with surface runoff. Pesticide levels alone were monitored at a third site in the Sutter Bypass. A companion study was conducted to monitor pesticide levels and toxicity in the San Joaquin River watershed (Ganapathy, 1998) and these results will be presented in a separate memorandum. Long-term monitoring of acute and chronic toxicity in these watersheds will help scientists at DPR evaluate the effectiveness of programs designed to decrease the runoff of dormant spray insecticides.

MATERIALS AND METHODS

Study Site Description

Wadsworth Canal

The Wadsworth Canal site is located 3.5 miles above the confluence with the Sutter Bypass, at a weir, just upstream of South Butte Road. This location continues to flow during periods of high discharge in the bypass and it receives runoff from the southern quarter of Butte County and northern Sutter County between the Feather River and the Sutter Buttes (Figure 3). The area is largely agricultural with numerous orchards to the east along the Feather River. Wadsworth Canal drains into the Sutter Bypass just above the Sutter National Wildlife Refuge and combines the flows of several streams and manmade canals. Two samples had to be collected from an alternate site at the Butte House Road bridge, 1.3 miles upstream of the primary site, due to the heavy accumulation of debris at the weir. There are no inputs in the area between the two sites on Wadsworth Canal.

Sutter Bypass

For the third consecutive year, we collected samples for chemical analysis from a small bridge across the western channel of the Sutter Bypass at the Karnak Pumping Station, just prior to the Sacramento Slough. This allowed us to obtain results that were comparable to the previous 2 years of dormant spray monitoring. Acute toxicity testing was not conducted at this site since it was performed on water from the smaller Wadsworth Canal location. The Sutter Bypass receives runoff water from most of the agricultural areas between the Sacramento and Feather Rivers (Figure 3). Previous studies have indicated the potential for high concentrations of pesticides in this area (Wofford and Lee, 1995). The alternate site for monitoring, when the Karnak site became flooded, was on the western edge of the Sutter Bypass at Kirkville Road, approximately 9 miles upstream from Karnak. Both sites had been used the first 2 years for our toxicity study. During the 1998-99 season, the Sutter Bypass at Karnak site was accessible for sampling from January 4 through January 18, all other samples were collected at Kirkville Road.

Sacramento River

The chronic toxicity monitoring site was located on the right bank of the Sacramento River at the Alamar Marina Dock, 9 miles below the confluence of the Feather River. This site receives discharge from all major agricultural tributaries but is above the confluence of the largely non-agricultural American River and the discharge of urban runoff from the cities of Sacramento and West Sacramento (Figure 3). This site was the same as the previous year.

Sample Collection

Background sampling was conducted during the week of December 7, 1998, prior to the onset of the dormant spray season. Dormant season sampling began on January 4 and continued through March 5, 1999, when no more dormant spray applications were reported.

Chemical analyses were performed on each water sample collected. Selected organophosphate and carbamate insecticides and soil applied herbicides were analyzed in three separate analyses with diazinon being analyzed in a fourth analysis (Table 1). Insecticides included in our analyses were chosen based on pesticide use reports indicating historical use during the dormant spray season in the Central Valley, previous detections in the watershed, the availability of analytical methods in the organophosphate or carbamate screens and to standardize analyses between the Sacramento and San Joaquin River studies. Herbicides included in our analyses were chosen based on historical use during the year in the Central Valley and the availability of analytical methods in a single screen.
Acute toxicity tests were performed twice per week, with samples collected on

Monday and Wednesday. One chronic toxicity test was conducted weekly using water samples collected on Monday, Wednesday, and Friday. Water collected on Monday was used to begin the chronic toxicity tests. Water collected on Wednesday and Friday was used to renew chronic test water (see below).

Water samples were collected at the Alamar, Karnak and Wadsworth Canal sites, from as close to center channel as possible, using a depth-integrated sampler (D-77) with a 3-liter Teflon® bottle and nozzle. This method was often unsuitable for use in the Sutter Bypass at Kirkville Road site. When the site was flooded, samples were collected by wading into the stream and utilizing a 1-liter bottle on the end of a 4-meter pole to collect subsurface grab samples.

Nine 1-liter splits were required for each sampling event. Approximately 12 liters of water were collected and composited in a stainless steel 10-gallon (38-liter) milk can. The composited sample was placed on wet ice for transportation back to the West Sacramento warehouse for splitting. All samples were split on the day of collection into 1-liter amber glass bottles, with Teflon® lined caps, using a (USGS designed) Geotech® 10-port splitter. One pair of 1-liter split samples from the Wadsworth Canal and Sacramento River sites were submitted for toxicity testing. Four 1-liter samples from each site were submitted for chemical analyses: one each for the organophosphate, carbamate, diazinon and herbicide analyses. Two 1-liter backups were stored at West Sacramento and 1-liter was used for acidification purposes.

Samples designated for organophosphate and carbamate chemical analysis were preserved by acidification with 3N hydrochloric acid to a pH of between 3.0 to 3.5. Most organophosphate and carbamate pesticides are sufficiently preserved at this pH (Ross et al., 1996). Diazinon, however, rapidly degrades under acidic conditions and therefore was analyzed from a separate, unacidified, sample. Herbicide samples are stable without acidification and were thus not acidified. Samples were stored in a 4° C refrigerator until transported to the appropriate laboratory (on wet ice) for analysis. All primary samples were delivered to the testing laboratory within 24 hours of collection.

Environmental Measurements

Water quality parameters measured *in situ* included temperature, pH, electrical conductivity (EC), and dissolved oxygen (DO). Water pH was measured using a Sentron® (model 1001) pH meter. EC was measured using a Orion® conductivity-salinity meter (model 140). Water temperature and DO were measured using a YSI dissolved oxygen meter (model 57). Additionally, ammonia, alkalinity and hardness were measured by the DFG Aquatic Toxicity Laboratory upon the delivery of the toxicity samples. Total ammonia was measured with an Orion® multi-parameter meter (model 290A) fitted with an Orion® ammonia ion selective electrode (model 95-12). Totals of alkalinity and hardness were measured with a Hach® titration kit.

Precipitation and discharge information were gathered for the study area. Precipitation data were averaged from two sites to approximate rainfall in the Sacramento Valley. The sites were located at a Department of Forestry station near Chico and a National Weather Service station at the Sacramento Post Office (stations CHI and SPO, respectively). Discharge was measured at the Wadsworth Canal each time a sample was collected. Discharge from the Butte-Slough-near-Meridian and the Tisdale Bypass gages were used to provide flow estimates for both Sutter Bypass sites. Discharge from the Verona USGS gaging station was used to estimate flow for the Sacramento River at Alamar Marina. The Verona site captures all major inputs to the Sacramento River above the sampling site. All precipitation and discharge data were taken from provisional, DWR, National Weather Service, USGS, and Department of Forestry information and is subject to revision. Further refinements of flow data at each site will be investigated for the final report as more information becomes available. This information will be used to follow annual changes in chemical concentrations with respect to fluctuations in flow and will also be useful for modeling efforts, should they be undertaken.

Chemical Analysis and Toxicity Testing

Chemical Analyses

Pesticide analyses of water samples were performed by the CDFA Center for Analytical Chemistry. The organophosphate insecticides were analyzed using gas chromatography (GC) and a flame photometric detector (FPD). The carbamate insecticides and the herbicides were analyzed using high performance liquid chromatography (HPLC), post column-derivatization and a fluorescence detector. The herbicides were analyzed by HPLC with a UV detector, and GC with a nitrogen phosphorus detector (NPD). The pesticides and reporting limits are listed in Table 1. Details of chemical analytical methods will be provided in the final report.

Quality control (QC) for the chemistry portion of this study was in accordance with Standard Operating Procedure QAQC001.00 (DPR, 1996) and consisted of a continuing QC program, plus the submission of 12 rinse blanks of the splitting equipment and 38 blind spikes submitted for the Sacramento and San Joaquin studies combined. Continuing QC results for each of the analytical screens are presented in Tables 2 through 7. Study 178 and 179 refer to the Sacramento and San Joaquin River studies, respectively. There were no detections of any pesticides in any of the 12 rinse blank samples. The 38 blind spikes, submitted along with the field samples from the two studies for analysis, contained 54 chemical analytes. More detailed quality control data, including method development, the establishment of control limits and spike recoveries, will be included in the final report.

Toxicity Tests

Acute toxicity testing was conducted by the DFG Aquatic Toxicity Laboratory following current U.S. Environmental Protection Agency (U.S.EPA) procedures using the cladoceran *Ceriodaphnia dubia* (U.S.EPA, 1993). Acute toxicity was determined using a 96-hour, static-renewal bioassay in undiluted sample water.

Chronic toxicity was determined using a static-renewal 7-day bioassay of undiluted sample water with *C. dubia* and followed current U.S.EPA guidelines (U.S.EPA, 1994). Test organisms used in chronic testing were placed in sample water on day one of testing, with test water replenished on days three and five. All acute and chronic tests commenced and renewal water was used within 36 hours of sample collection except for one chronic test. That test failed due to control sample mortality and was restarted outside the 36-hour window. Data were reported as percent survival for both acute and chronic tests and the average number of offspring per adult for the chronic tests. More complete information on chemical analytical and bioassay methods will be provided in the final report.

RESULTS

Environmental Measurements

Wadsworth Canal

Figure 5 presents the data for pH, ammonia, DO, temperature, EC, alkalinity and hardness for the Wadsworth Canal site. Ammonia levels were below the detection limit of 50 μg/L 55% of the time but were as high as 180 μg/L. pH values ranged from 7.4 to 8.0. Water temperature ranged from 7.5 to 14.1° C, DO ranged from 7.5 to 10.8 mg/L and EC ranged from 231 to 577 μS/cm. Alkalinity ranged from 102 to 270 mg/L and hardness ranged from 98 to 272 mg/L.

Sampling crews frequently smelled diesel oil when clearing debris buildups from the Wadsworth Canal site prior to gaging the site and oil could be observed on the water. This oil was likely the residue of a spill which occurred late in 1998, with the presence of oil being noted periodically through the last week of the study. No quantifiable or qualitative measurement of this oil was attempted.

Sutter Bypass

Figure 6 presents the data for pH, DO, temperature, and EC for the Sutter Bypass sites. pH values ranged from 7.2 to 7.8. Water temperature ranged from 5.9 to 11.1° C, DO ranged from 8.4 to 11.1 mg/L and EC ranged from 105 to 352 μS/cm. Ammonia, alkalinity and hardness were not measured.

Sacramento River

Figure 7 presents the data for pH, DO, temperature, EC, alkalinity and hardness for the Sacramento River at Alamar Marina site. Except for the February 1 sample which reached 62 μg/L, ammonia levels remained below the detection limit of 50 μg/L for all samples. pH values ranged from 6.8 to 7.8. Water temperature ranged from 6.8 to 10.9° C, DO ranged from 10.1 to 11.6 mg/L and EC ranged from 90 to 162 μS/cm. Alkalinity ranged from 36 to 66 mg/L and hardness ranged from 40 to 70 mg/L.

Figure 8 presents precipitation averaged for two stations in the Sacramento Valley and discharge for the Sacramento River and the Sutter Bypass. Wadsworth Canal discharge is not presented in the figure, because it is at least an order of magnitude lower than at the other two sites. Discharge at Wadsworth Canal is included in Table 7. All discharge data presented in Figure 8 are based on preliminary data and are approximate as all inputs and diversions were not gaged and many gages are not accurately calibrated at extreme flows (personal communication: Steven Graham, DWR Surface Water Unit). The estimated discharge in the Sutter Bypass peaked at 44,000 cfs and the discharge in the Sacramento River at Verona peaked at 64,000 cfs. Inputs from sources such as Wadsworth Canal and Gilsizer Slough would increase the Sutter Bypass discharges presented here, but during high bypass flows these inputs would be insignificant. Measured discharge at Wadsworth Canal peaked at 330 cfs at a time when the total Sutter Bypass discharge was over 15,000 cfs. Typical Wadsworth Canal discharge ranged from 53 to 173 cfs.

Chemical Concentrations and Toxicity Data

Wadsworth Canal

Diazinon was detected in 17 of the 20 samples collected from the Wadsworth Canal (Table 7). Diazinon was first detected on January 4 and continued to be detected in every sample through March 1. Diazinon levels ranged from 0.04 to 1.6 µg/L with an average concentration of 0.432 µg/L for the 17 detections. Methidathion was detected once on January 20 at 0.051 µg/L. No other insecticides were detected. Herbicides were detected in 14 of the 20 samples, including the two background samples. Diuron was the most commonly detected herbicide. It was detected in all 14 samples where herbicides were detected with the maximum concentration of 1.13 µg/L and an average concentration of 0.22 µg/L. Bromacil and hexazinone were each detected 3 times and simazine 5 times. The highest concentrations for these herbicides were 0.189, 0.36, and 0.228 µg/L for bromacil, hexazinone, and simazine respectively. All four of these herbicides were detected in the February 10 sample.

Eight of the 20 samples were acutely toxic to *C. dubia*. Complete mortality was observed in seven of the samples and one sample had statistically significant reductions in survival. Diazinon was detected in all of the samples that demonstrated significant mortality but was also detected in nine samples that did not show significant mortality. A diazinon concentration of roughly 0.2 µg/L appeared to correspond to a threshold where toxic effects occurred. Possible relationships between the occurrence of pesticides and aquatic toxicity will be investigated in the final report.

Sutter Bypass

Diazinon was detected in 9 of the 20 samples collected in the Sutter Bypass (Table 8). Diazinon was first detected at Karnak on January 11 at 0.065 µg/L. Diazinon continued to be detected in the Sutter Bypass until February 8, at levels ranging from 0.041 to 0.11 µg/L, with an average concentration of 0.08 µg/L. Diuron was detected twice in February at 0.08 and 0.1 μg/L. No other insecticides or herbicides were detected.

Sacramento River

No insecticides were detected in any of the 30 samples collected from the Sacramento River at Alamar Marina (Table 8). Diuron was detected in 11 (36%) of the samples starting with the January 18 sample. The highest observed diuron concentration was 0.3 μg/L with an average concentration of 0.129 μg/L. No other pesticides were detected.

Except for the January 4 - 8 samples, no chronic toxicity test had less than 80% survival and all produced between 12 and 26 offspring per adult female at the end of the test. No control showed less than 90% survival and fecundity varied between 18 and 25 offspring (Table 9). The January 4 - 8 test had to be restarted 78 hours after sample collection due to poor survival in the control. In this restarted test, 30% *C. dubia* survival and 5 offspring per adult were observed in the sample while 90% survival and 21 offspring were observed in the control. No pesticides were detected in this sample. Statistical analysis of survival and reproduction data will be included in the final report.

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Table 1. California Department of Food and Agriculture, Center for Analytical Chemistry organophosphate and carbamate insecticide and triazine herbicide screens for the Sacramento River toxicity monitoring study.

Organophosphate Pesticides in Surface Water by GC Method: GC/FPD		**N-Methyl Carbamate in Surface Water by HPLC Method: HPLC/Post Column-fluorescence**		**Herbicides in Surface Water by HPLC Method: HPLC/UV detector and GC/NPD**	
Compound	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**	**Compound**	**Reporting Limit (µg/L)**
Chlorpyrifos	0.04	Carbaryl	0.05	Atrazine	0.05
Diazinon[1]	0.04	Carbofuran	0.05	Bromacil	0.05
Dimethoate (Cygon)	0.05			Diuron	0.05
Fonofos	0.05			Cyanazine	0.2
Malathion	0.05			Hexazinone	0.2
Methidathion	0.05			Metribuzin	0.2
Methyl parathion	0.05			Prometon	0.05
Phosmet	0.05			Prometryn	0.05
				Simazine	0.05

[1] Diazinon was analyzed from a separate, unpreserved, split sample. Other OP and CB chemical samples were preserved with 3N HCl to a pH of 3-3.5 to retard analyte degradation. See text.

Table 2. Blind Spike Recoveries for the San Joaquin River and Sacramento River Studies

Extraction Date	Study Number[a]	Sample Number	Screen	Pesticide	Spike Level	Recovery	Percent Recovery	Exceed CL[b]
1/19/1999	178	169	OP	Fonofos	0.2	0.173	86.5	
				Phosmet	0.5	0.500	100	
1/19/1999	178	170	CB	Carbaryl	0.1	0.105	105	UCL
				Carbofuran	0.2	0.188	94.0	
1/19/1999	178	171	DI	Diazinon	0.1	0.088	88.0	
1/19/1999	179	169	OP	Dimethoate	0.2	0.194	97.0	
				Methidathion	0.1	0.105	105	
1/19/1999	178	172	TR	Hexazinone	0.5	0.528	106	
				Prometryn	0.3	0.306	102	
1/21/1999	179	170	DI	Diazinon	0.2	0.188	94.0	
1/22/1999	179	171	TR	Simazine	0.5	0.503	101	
				Bromacil	0.2	0.248	124	UCL
1/26/1999	179	172	OP	Chlorpyrifos	0.2	0.186	93.0	
				Methyl Parathion	0.2	0.191	95.5	
1/28/1999	179	174	TR	Prometryn	0.5	0.505	101	
				Atrazine	0.2	0.198	99.0	
1/29/1999	179	173	DI	Diazinon	0.3	0.268	89.3	
2/2/1999	178	233	OP	Dimethoate	0.2	0.206	103	
				Malathion	0.2	0.199	99.5	
2/2/1999	178	234	CB	Carbaryl	0.2	0.182	91.0	
				Carbofuran	0.2	0.203	102	UCL
2/4/1999	179	283	OP	Chlorpyrifos	0.2	0.179	89.5	
				Methidathion	0.3	0.290	96.7	
2/9/1999	178	253	DI	Diazinon	0.1	0.100	100	
2/11/1999	178	235	OP	Chlorpyrifos	0.2	0.125	62.5	LCL
				Fonofos	0.3	0.206	68.7	LCL
2/11/1999	178	236	CB	Carbaryl	0.2	0.178	89.0	
				Carbofuran	0.2	0.175	87.5	
2/16/1999	178	254	TR	Diuron	0.2	0.213	107	
				Metribuzine	0.5	0.525	105	UCL
2/22/1999	179	285	TR	Cyanazine	0.5	0.42	84.0	
				Bromacil	0.2	0.167	83.5	LCL
2/22/1999	178	240	TR	Prometon	0.3	0.26	86.7	
				Simazine	0.5	0.415	83.0	
2/23/1999	178	238	CB	Carbaryl	0.3	0.289	96.3	
2/23/1999	178	239	DI	Diazinon	0.15	0.139	92.7	
2/23/1999	178	237	OP	Methyl Parathion	0.3	0.274	91.3	
				Phosmet	0.2	0.209	105	
2/23/1999	179	284	DI	Diazinon	0.2	0.171	85.5	
2/25/1999	178	242	CB	Carbofuran	0.3	0.235	78.3	
2/25/1999	178	244	TR	Simazine	0.5	0.427	85.4	
2/25/1999	178	241	OP	Methidathion	0.2	0.212	106	
2/26/1999	178	243	DI	Diazinon	0.2	0.165	82.5	
3/1/1999	179	340	TR	Bromacil	0.2	0.172	86.0	LCL
3/2/1999	179	337	OP	Chlorpyrifos	0.2	0.191	95.5	
3/2/1999	178	486	TR	Diuron	0.3	0.25	83.3	
3/2/1999	178	483	OP	Chlorpyrifos	0.3	0.228	76.0	
3/2/1999	178	485	DI	Diazinon	0.15	0.128	85.3	
3/2/1999	179	339	DI	Diazinon	0.3	0.292	97.3	
3/2/1999	179	338	CB	Carbofuran	0.2	0.157	78.5	LCL
3/2/1999	178	484	CB	Carbaryl	0.2	0.186	93.0	
3/4/1999	179	341	OP	Dimethoate	0.2	0.196	98.0	
3/4/1999	179	342	TR	Cyanazine	0.5	0.483	96.6	
3/8/1999	178	487	OP	Dimethoate	0.3	0.307	102.3	

[a] 178 refers to the study number for the Sacramento River, 179 refers to the SJR.

[b] CL=Control Limit; Upper CL (UCL), Lower CL (LCL). Control Limits for the individual pesticides are listed on tables 3 through 6.

Table 3. Continuing Quality Control- Organophosphate Screen

Extraction Date	Sample Numbers	Percent Recovery Chlorpyrifos	Diazinon	Dimethoate	Fonofos	Malathion	Methidathion	Methyl Parathion	Phosmet
12/11/1998	178-1,7,19,25,31;179-1,7,13,9	83.8	80.0	98.0	66.0*	96.0	91.0	89.0	93.0
12/14/1998	178-37;179-25	105	103.0	111.0	95.0	105.0	104.0	110.0	112.0
1/5/1999	178-43,50,57;179-31,38	90.0	86.3	107.0	82.0	94.0	102.0	93.0	108.0
1/7/1999	178-63,70,76;179-45,52	85.0	88.8	91.0	88.0	87.0	88.0	92.0	89.0
1/11/1999	178-83,90;179-59	96.3	96.3	94.0	94.0	98.0	99.0	97.0	98.6
1/12/1999	178-94,101,107;179-66,73	98.8	98.8	97.0	93.0	99.0	101.0	98.0	102.8
1/14/1999	178-113,120,126;179-80,87	92.5	87.5	89.0	82.0	92.0	91.0	90.0	95.2
1/19/1999	178-133,140,146, 152,169; 179-94,100,106	77.5	72.5	72.0	69.0	80.0	82.0	77.0	82.4
1/21/1999	178-158,164,174;179-94,100,106	103	104.0	93.0	100.0	105.0	107.0	102.0	97.4
1/26/1999	178-180,186,192,198; 179-142,130, 136,142,172	90.0	88.8	97.0	82.0	92.0	91.0	90.0	90.2
1/28/1999	178-136,143,149, 155;179-97,103,109	98.8	91.3	97.0	88.0	97.0	93.0	95.0	85.4
1/28/1999	178-204,210,214, 220;179-148,154	104	98.8	99.0	97.0	105.0	101.0	101.0	94.4
2/2/1999	178-226,232,233, 260,266; 179-160,175,181	88.8	83.8	86.0	83.0	90.0	90.0	88.0	87.0
2/2/1999	178-161,167,177	83.8	82.5	87.0	74.0	89.0	91.0	84.0	92.0
2/9/1999	178-290,296,302, 306,312; 179-200,206,212	82.5	80.0	88.0	73.0	86.0	88.0	84.0	88.4
2/4/1999	178-272,278,284; 179-166,190,196,283	86.3	83.8	86.0	74.0	92.0	91.0	87.0	89.8
2/11/1999	178-235,318,324, 328,334;179-218,224	93.8	91.3	96.0	83.0	79.0	96.0	95.0	97.0
2/16/1999	178-340,346,352, 358;179-230,236,242	85.0	81.3	91.0	77.0	89.0	90.0	85.0	91.0
2/18/1999	178-364,370,376; 179-249,254	92.5	88.8	92.0	87.0	95.0	96.0	92.0	96.0
2/23/1999	178-237,382,388, 394,398,404; 179-260,266,270,276	93.8	93.8	92.0	93.0	94.0	94.0	92.0	93.8
2/25/1999	178-241,410,416, 422; 179-282,294,300	88.8	87.5	86.0	81.0	93.0	88.0	89.0	92.6
3/2/1999	178-428,434,438, 444,450,483;179-304,310,316,337	97.5	96.3	87.0	94.0	99.0	100.0	97.0	97.2
3/4/1999	178-456,462,468; 179-322,325,341,346	95.0	93.8	99.0	93.0	98.0	103.0	97.0	92.6
3/8/1999	178-474,480,487; 179-329	95.0	91.3	94.0	95.0	98.0	97.0	96.0	91.4
Average Recovery		91.9	89.6	92.9	86.0	93.8	94.8	92.5	94.1
Standard Deviation		7.16	7.73	7.76	8.74	6.88	6.28	6.96	6.68
CV		7.79	8.63	8.36	10.17	7.33	6.63	7.52	7.10
Upper Control Limit		112	109	120	111	113	120	118	120
Upper Warning Limit		106	103	113	103	107	113	111	113
Lower Warning Limit		81.8	77.6	85.6	73.6	82.3	83.8	82.7	84.5
Lower Control Limit		75.7	71.4	78.8	66.3	76.1	76.6	75.7	77.4

*Highlighted cells are percent recoveries exceeding control limits

All percentage recoveries and control limits have been rounded to three significant figures.

Table 4. Continuing Quality Control-Carbamate Screen

Extraction Date	Sample Numbers	Percent Recovery Carbofuran	Percent Recovery Carbaryl
12/8/1998	178-2,8,14;179-2,8	88.8	94.0
12/10/1998	178-20,26,32; 179-14,20	89.4	98.2
12/14/1998	178-38;179-26	97.0	97.0
1/6/1999	178-44,51,58; 179- 32,39	90.4	95.0
1/7/1999	178-64,71,77;179-46,53	87.9	98.1
1/12/1999	178-84,91,95, 102,108;179-60,67,74	92.7	101*
1/14/1999	178-114,121,127; 179-81,88	90.1	98.0
1/19/1999	178-134,141,147,153, 170; 179-95,101,107	98.1	93.6
1/21/1999	178-175,165,159; 179-119,113	102.0	103.0
1/26/1999	178-182,187,195,199; 179-125,131,143	104.0	106.0
1/28/1999	178-205,211,215,221; 179-149,155	101.0	96.8
2/2/1999	178-227,234,255, 261,267; 179-161,176,182	91.7	97.1
2/4/1999	178-273,279,285; 179-167,191,197	90.4	96.2
2/9/1999	178-291,297,303, 307,313; 179-201,207,213	90.2	102.0
2/11/1999	178-236,319,325, 329,335;179-219,225	88.4	89.6
2/16/1999	178-341,347,353, 359;179-231,237,243	96.2	99.4
2/18/1999	178-365,371,377; 179-249,255	92.1	99.4
2/23/1999	178-238,383,389, 395,399,405; 179-261,267,271,277	101.0	99.5
2/25/1999	178-242,411,417,423; 179-289,295,299	85.7	99.3
3/2/1999	178-429,435,439, 445,451,484; 179-305,311,317,338	93.0	98.9
3/4/1999	178-457,463,469; 179-323,326,347	92.1	101.0
3/8/1999	178-475,481; 179-330	83.2	97.6
Average Recovery		93.0	98.1
Standard Deviation		5.5	3.5
CV		5.9	3.6
Upper Control Limit		99.8	99.5
Upper Warning Limit		95.7	96.0
Lower Warning Limit		79.2	82.2
Lower Control Limit		75.0	78.2

*Highlighted cells are percent recoveries exceeding control limits

All recovery percentages have been rounded to three significant figures.

Table 5. Continuing Quality Control-Diazinon Analysis

Extraction Date	Sample Numbers	Percent Recovery Diazinon
12/9/1998	178-3,9,15;179-3,9	97.5
12/10/1998	178-21,27,33;179-15,21	78.8
12/14/1998	178-39; 179-27	91.3
1/7/1999	178-45,52,59, 65,72,78; 179-33,40,47,54	87.5
1/11/1999	178-85,92; 179-61	92.5
1/12/1999	178-96,103,109; 179-68,75	93.8
1/14/1999	178-115,122,128; 179-82,89	87.5
1/19/1999	178-135,148,154, 171;179-82,89	78.8
1/21/1999	178-160,166,176; 179-114,120,170	103.0
1/22/1999	179-122	101.0
1/26/1999	178-181,184,188, 194,200; 179-126, 132, 138,144	88.8
1/29/1999	178-206,212,216, 222; 179-150,156,173	90.0
2/2/1999	178-162,168,178	88.8
2/3/1999	178-228,256,262, 268: 179-162,177,183	96.3
2/4/1999	178-274,280,286; 179-168,192,198	92.5
2/9/1999	178-253,292,298, 304,308,314; 179-202,208,214	91.3
2/11/1999	178-320,326,330, 336; 179-220,226	92.5
2/16/1999	178-342,348,354, 360; 179-232,238,244	88.8
2/18/1999	178-366,372,378; 179-250,256	88.8
2/23/1999	178-239,384,396,400, 406; 179-262,268, 272,278,284	95.0
2/26/1999	178-243,412,418, 424; 179-290,296,298	93.8
3/2/1999	178-430,436,440, 446,452,485; 179-306,312,318,339	88.8
3/4/1999	178-458,464,470; 179-324,327,348	95.0
3/8/1999	178-476,482; 179-331	95.0
Average Recovery		91.5
Standard Deviation		5.6
CV		6.1
Upper Control Limit		109
Upper Warning Limit		103
Lower Warning Limit		77.6
Lower Control Limit		71.4

Table 6. Continuing Quality Control- Triazine/Diuron/Bromacil Screen

Extraction Date	Sample Numbers	Percent Recovery					All figures rounded to three significant digits.			
		Atrazine	Bromacil	Diuron	Cyanazine	Hexazinone	Metribuzin	Prometon	Prometryn	Simazine
1/5/1999	178-48,55,62; 179-35,43	94.0	115.0*	106.8	101.0	105.0	88.6	98.8	94.6	91.6
1/5/1999	178-48,55,62; 179-35,43	100.0	111.0	97.0	97.0	110.0	90.0	87.0	76.0	95.0
1/8/1999	178-68,75,81; 179-35,43	100.0	112.0	118.0	98.8	109.0	103.0	86.0	71.0	82.6
1/8/1999	178-68,75,81; 179-50,57	99.0	102.8	113.6	96.4	113.6	100.0	87.4	84.6	91.8
1/11/1999	178-88,93; 179-64	80.0	120.0	92.0	80.3	103.0	87.0	111.0	108.0	108.0
1/11/1999	178-88,93; 179-64	78.8	92.6	95.0	84.4	105.2	90.4	82.6	90.6	82.4
1/13/1999	178-99,106,112; 179-71,78	97.0	99.0	105.0	95.0	111.0	90.3	93.0	104.0	107.0
1/14/1999	178-118,125,131; 179-85,91	82.0	88.0	99.0	83.5	115.0	88.0	91.0	99.0	88.0
1/15/1999	178-4,10,16,24, 36,42; 179-6,12,18,24,30	95.0	110.0	103.0	99.8	110.0	102.0	89.0	91.0	96.0
1/19/1999	178-138,145,151, 157,172; 179-99,105, 111	114.0	93.0	103.0	86.0	109.0	86.5	107.0	112.0	87.0
1/22/1999	178-163,173,179; 179-123,171	102.0	117.0	100.0	97.3	112.0	90.0	99.7	106.0	107.0
1/25/1999	178-185; 179-129,135	100.0	121.0	89.0	105.0	104.0	94.8	98.0	100.0	105.0
1/28/1999	178-209,213,219,225; 179-159,174	96.0	117.0	103.0	102.3	103.0	93.5	101.0	110.0	96.0
1/26/1999	178-191,203; 179-141,147	92.0	99.0	106.0	96.0	100.0	87.5	95.0	103.0	95.0
1/29/1999	178-231; 179-165	91.0	102.0	94.0	92.3	94.8	89.3	88.0	108.0	93.0
2/2/1999	178-259,265,271; 179-180,186	100.0	103.0	80.0	105.0	96.0	86.8	112.0	109.0	109.0
2/4/1999	178-277,283,289; 179-189,195,199	86.0	107.0	76.0	87.8	94.8	77.0	89.0	87.0	110.0
2/16/1999	178-254,295,301,305, 311,317,323,327,333, 339	95.0	87.0	104.0	94.3	97.5	91.5	113.0	103.0	103.0
2/17/1999	179-205,211,217, 223,229	94.0	90.0	98.0	94.3	99.8	89.3	84.0	82.0	98.0
2/17/1999	178-345,351,357, 363; 179-235,241,247	89.0	98.0	97.0	96.5	105.0	89.5	78.0	79.0	93.0
2/18/1999	178-369,375,381; 179-253,259	106.0	111.0	105.0	97.8	99.0	91.5	100.0	95.0	109.0
2/22/1999	178-240,387;179-265,269,285	103.0	103.0	93.0	95.3	95.3	91.5	105.0	118.0	119.0
2/22/1999	178-393,397,403, 409; 179-275,281	103.0	104.0	108.0	92.8	96.5	87.3	98.0	88.0	101.0
2/25/1999	178-244,415,421, 427; 179-293,297,303	94.0	97.0	99.0	92.3	92.0	85.0	87.0	88.0	94.0
3/1/1999	178-433,437; 179-309,340	93.0	105.0	106.0	99.5	101.0	96.8	109.0	109.0	112.0
3/2/1999	178-443,449,455, 486; 179-315,321	94.0	119.0	123.0	87.3	99.8	92.0	111.0	109.0	118.0
3/4/1999	178-461,467,473; 179-328,342,345,351	91.0	97.0	115.0	92.5	102.0	94.3	80.0	81.0	102.0
Average Recovery		95.1	104.1	101.1	94.4	103.1	90.9	95.6	96.5	99.8
Standard Deviation		7.8	10.0	10.4	6.3	6.4	5.4	10.5	12.6	10.0
CV		8.25	9.61	10.28	6.70	6.24	5.91	10.99	13.08	9.98
Upper Control Limit		121.0	109.0	117.0	121.0	123.0	105.0	109.0	115.0	126.0
Upper Warning Limit		114.0	103.0	108.0	114.0	115.0	101.0	103.0	108.0	118.0
Lower Warning Limit		85.0	92.1	74.6	87.4	84.5	84.5	92.1	79.1	86.4
Lower Control Limit		77.7	86.5	66.2	80.7	76.8	80.4	86.5	71.9	78.5

*Highlighted cells are percent recoveries exceeding control limits

Table 7. Results of sampling at Wadsworth Canal for the Sacramento River Watershed Toxicity Study, Winter 1998-99. Only pesticides detected at a site during this sampling season are shown.

Table 7 Wadsworth Canal

Sampling Date	Diazinon (μg/L)	Methida-thion (μg/L)	Bromacil (μg/L)	Diuron (μg/L)	Hexazinone (μg/L)	Simazine (μg/L)	Measured Discharge (cfs)	Acute Toxicity Percent Survival[1]
12/7/98	nd[2]	nd	nd	0.320	nd	nd	-	90/100
12/9/98	nd	nd	nd	0.266	nd	nd	-	95/95
1/4/99	0.124	nd	nd	nd	nd	nd	51	75/100
1/6/99	0.228	nd	nd	nd	nd	nd	64	0/100[3]
1/11/99	0.216	nd	nd	nd	nd	nd	73	50/90[4]
1/13/99	0.163	nd	nd	0.145	nd	nd	68	95/100
1/18/99	0.321	nd	nd	0.142	nd	nd	72	0/100[3]
1/20/99	0.329	0.051	0.175	0.262	nd	nd	83	0/90[3]
1/25/99	0.155	nd	nd	nd	nd	nd	95	100/90
1/27/99	0.211	nd	nd	nd	nd	nd	53	45/95[3]
2/1/99	1.11	nd	0.189	0.130	nd	nd	66	0/90[3]
2/3/99	0.154	nd	nd	nd	nd	nd	56	100/100
2/8/99	1.61	nd	nd	0.186	0.261	0.220	113	0/95[3]
2/10/99	1.02	nd	0.126	1.13	0.360	0.228	172	0/100[3]
2/15/99	0.132	nd	nd	0.076	nd	nd	74	100/100
2/17/99	1.27	nd	nd	0.168	0.329	0.162	330	0/100[3]
2/22/99	0.177	nd	nd	0.186	nd	0.096	160	90/95
2/24/99	0.082	nd	nd	0.102	nd	nd	132	100/100
3/1/99	0.044	nd	nd	0.087	nd	0.103	129	100/100
3/3/99	nd	nd	nd	0.053	nd	nd	101	100/90

Notes to Table 7:

[1] Two numbers are reported for all toxicity tests. The first number is the result from the sample, the second is the result from the corresponding control. The numbers reported for percent survival refers to the survival at the end of the test.

[2] nd = none detected at the reporting limit for that chemical.

[3] The differences in survival between the sample and the corresponding control are statistically significant at $p < 0.05$.

[4] For the January 11, 1999 test, $p = 0.0593$.

Table 8. Results of Sacramento River Watershed Toxicity Study, Winter 1998-99 for the Sacramento River at Alamar and the Sutter Bypass at Karnak/Kirkville Road. Only pesticides detected at a site during this sampling season are shown. No other pesticides in the organophosphate, carbamate or herbicide screens were detected.

Table 8	SACRAMENTO RIVER			SUTTER BYPASS		
Sampling Date	Diuron (µg/L)	Chronic Toxicity Percent Survival[1]	Chronic Toxicity Offspring /animal[1]	Site	Diazinon (µg/L)	Diuron (µg/L)
12/7/98	nd[2]	-		Kirkvl Rd	nd	nd
12/9/98	nd	-		Kirkvl Rd	nd	nd
12/11/98	nd	80/100	14/24			
1/4/99	nd	-		Karnak	nd	nd
1/6/99	nd	-		Karnak	nd	nd
1/8/99	nd	30/90[3,4]	5/21[4]			
1/11/99	nd	-		Karnak	0.072	nd
1/13/99	nd	-		Karnak	0.074	nd
1/15/99	nd	100/90	25/22			
1/18/99	0.061	-		Kirkvl Rd	0.11	nd
1/20/99	0.30	-		Kirkvl Rd	0.081	nd
1/22/99	0.249	90/100	19/21			
1/25/99	0.117	-		Kirkvl Rd	0.041	nd
1/27/99	0.072	-		Kirkvl Rd	0.042	nd
1/29/99	nd	80/100	18/21			
2/1/99	0.05	-		Kirkvl Rd	0.076	nd
2/3/99	nd	-		Kirkvl Rd	0.085	0.081
2/5/99	nd	90/100	18/25			
2/8/99	0.129	-		Kirkvl Rd	0.065	nd
2/10/99	0.166	-		Kirkvl Rd	nd	0.103
2/12/99	0.104	100/100	26/25			
2/15/99	nd	-		Kirkvl Rd	nd	nd
2/17/99	nd	-		Kirkvl Rd	nd	nd
2/19/99	nd	100/100	17/25			
2/22/99	nd	-		Kirkvl Rd	nd	nd
2/24/99	nd	-		Kirkvl Rd	nd	nd
2/26/99	nd	100/90[5]	21/23			
3/1/99	nd	-		Kirkvl Rd	nd	nd
3/3/99	nd	-		Kirkvl Rd	nd	nd
3/5/99	nd	78/100[5]	12/18			

Notes to Table 8:

[1] Two numbers are reported for all toxicity tests. The first number is the result from the sample, the second is the result from the corresponding control. Chronic toxicity water was replaced twice each week using new sample water . The numbers reported for percent survival refers to the survival at the end of the test. The number reported for offspring is the number of offspring produced divided by the number of adult animals used in the test.

Notes to Table 8 continued:

[2] nd = none detected at the reporting limit for that chemical.

[3] The differences in survival between the sample and the corresponding control are statistically significant at $p < 0.05$.

[4] This test had to be restarted 78 hours after sample collection due to high mortality in the control. The retest data are presented here although the start date exceeds the criteria for starting the test within 36 hours.

[5] One animal in the sample was inadvertently killed during the test, results are calculated based on nine animals in the test.

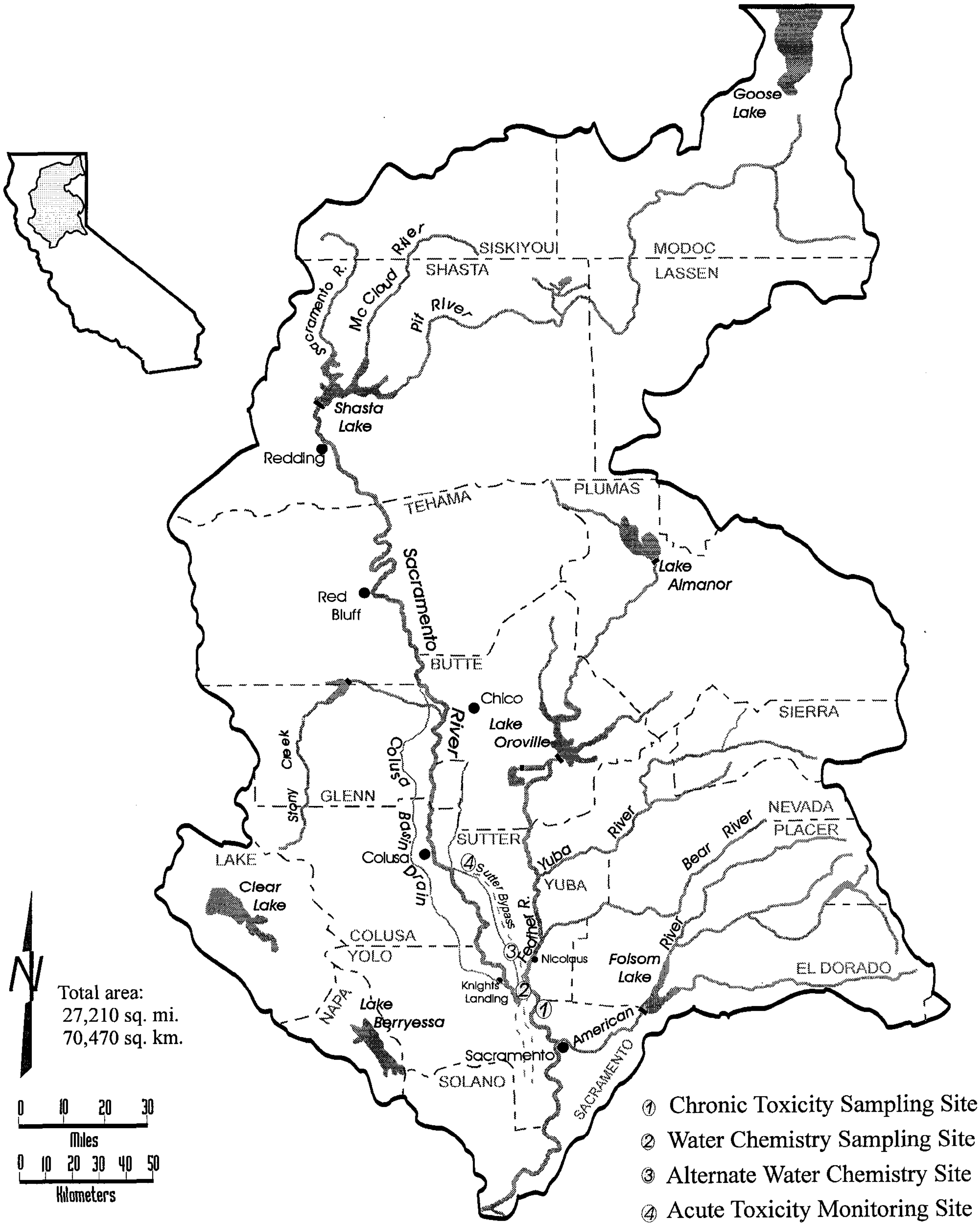


Figure 1. Map of the Sacramento River Hydrologic Basin.

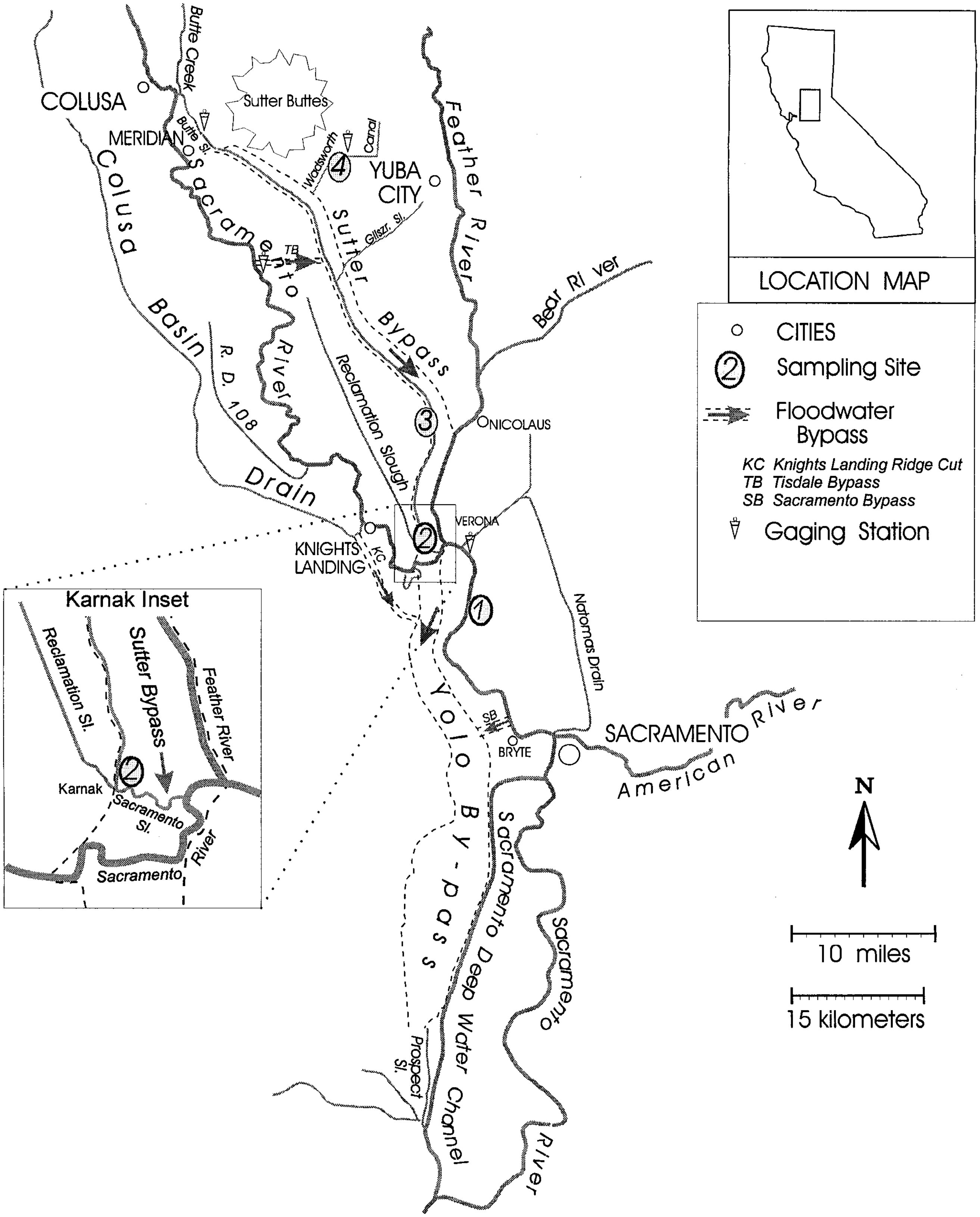


Figure 2: Sampling sites in the Sacramento River watershed.
Site 1 = Alamar Marina, Sacramento River Chronic Toxicity Site.
Site 2 = Sutter Bypass at Karnak Pumping Station, Water Chemistry Site.
Site 3 = Sutter Bypass at Kirkville Road, Alternate Water Chemistry Site.
Site 4 = Wadsworth Canal, Acute Toxicity Monitoring Site.

Hydrologic Basins Map

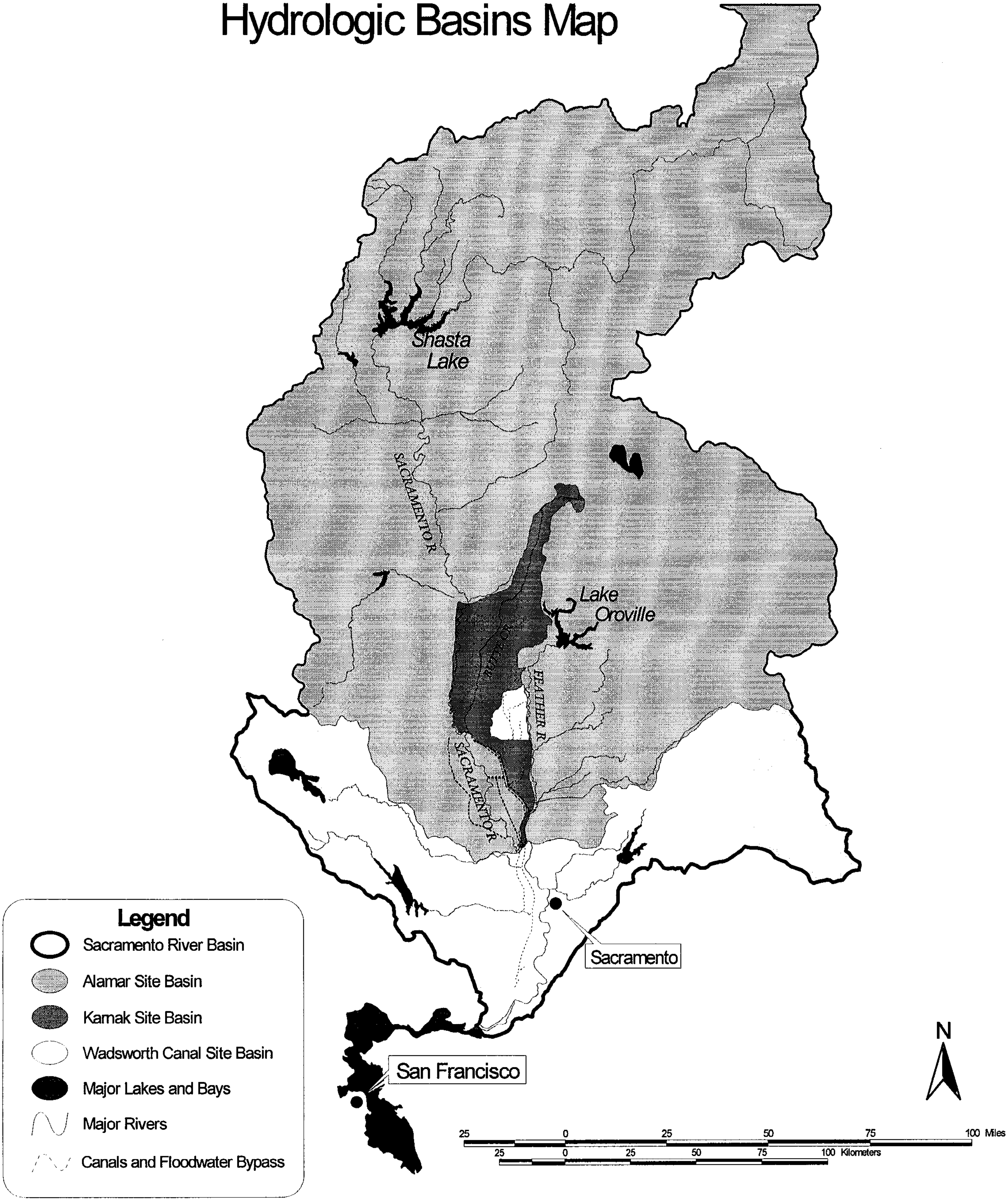
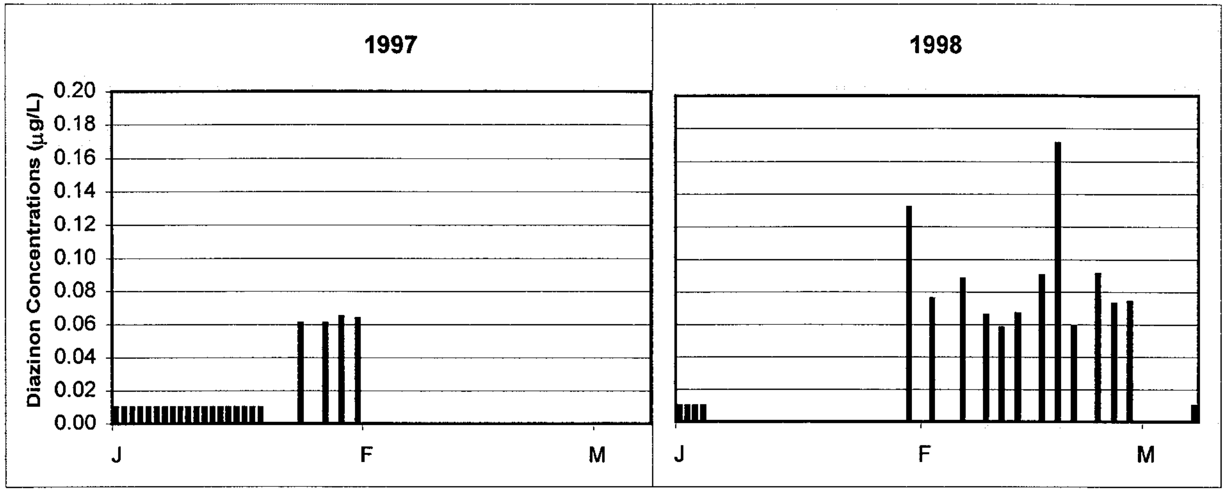


Figure 3. Map of the Hydrologic Basins for the sites used for the 1998-99 Dormant Spray Monitoring. Each basin includes the area of all the basins listed below it in the legend. When the alternate site at Kirkville Road is used, the hydrologic basin would include large areas of the "Alamar Basin" above Butte Creek due to the influx of Sacramento River water into the Sutter Bypass at Butte Creek and the Tisdale Weir.

HISTORICAL DORMANT SEASON DIAZINON DETECTIONS
SACRAMENTO RIVER



SUTTER BYPASS

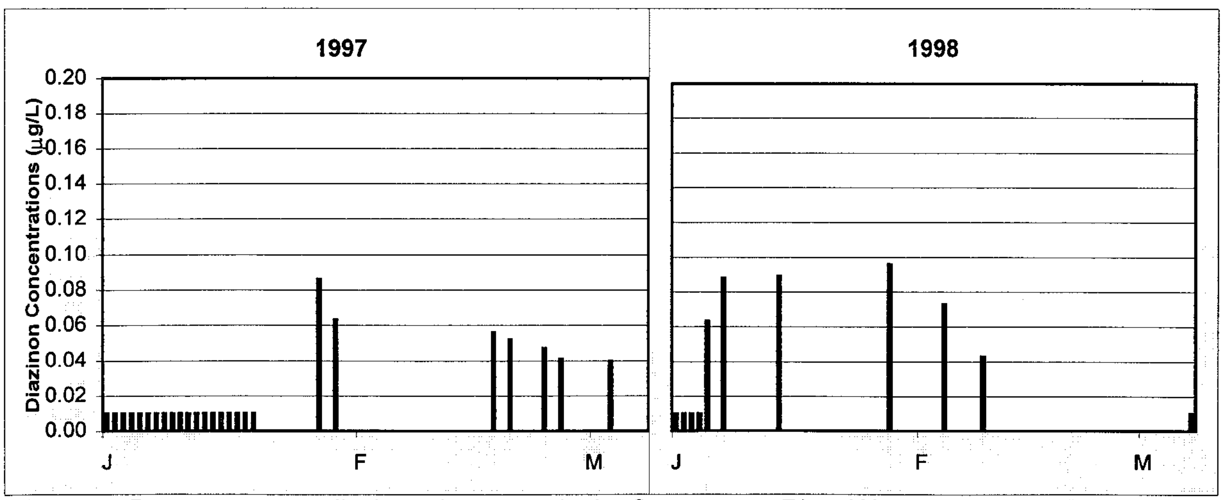


Figure 4. Dormant season diazinon detections in the Sacramento River Watershed by the Department of Pesticide Regulation, January 1-March 7.
Note: The reporting limit for diazinon is 0.04 µg/L. Concentrations of 0.01 denote dates within the January 1 to March 7 time frame when no samples were taken. For example, sampling in 1997 did not commence until January 20 due to severe flooding. Diazinon concentrations during these periods is unknown.

ENVIRONMENTAL DATA FOR THE WADSWORTH CANAL, WINTER 1998-99

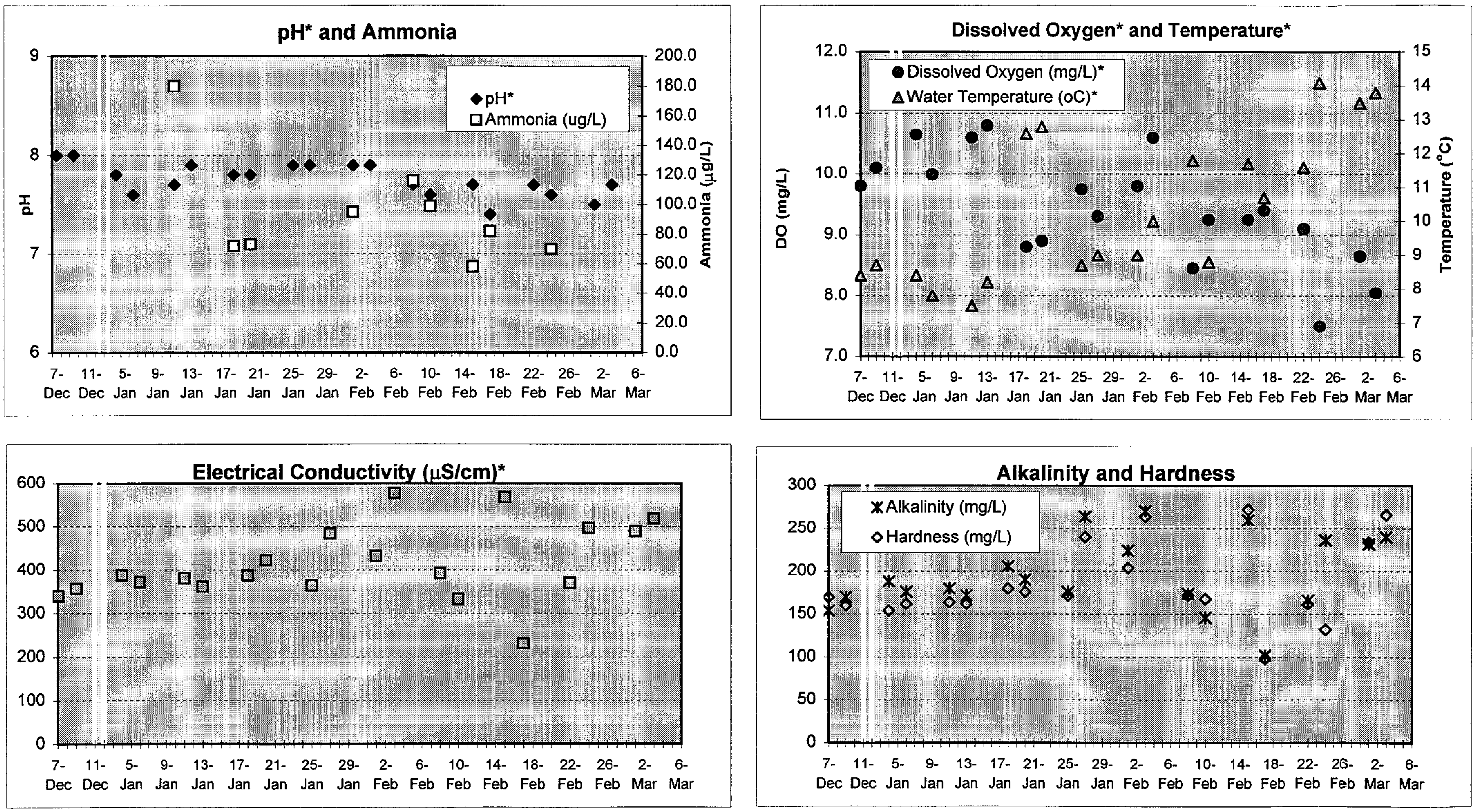
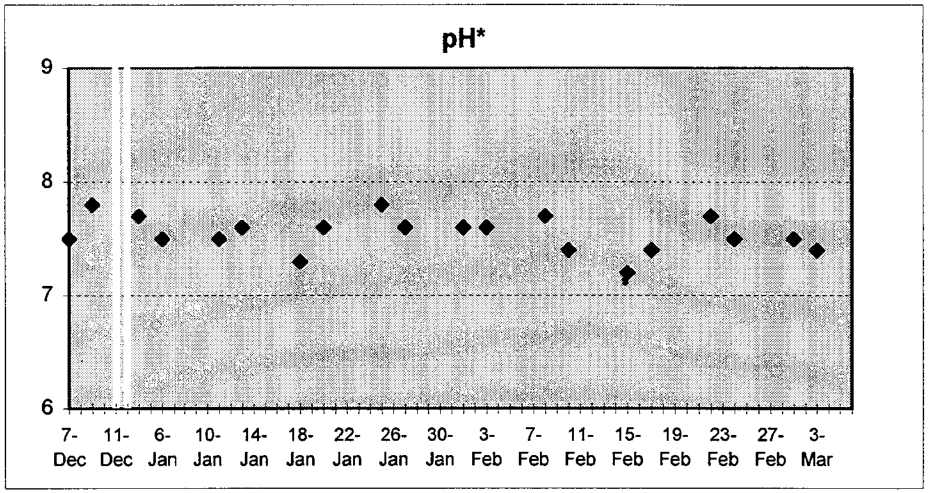
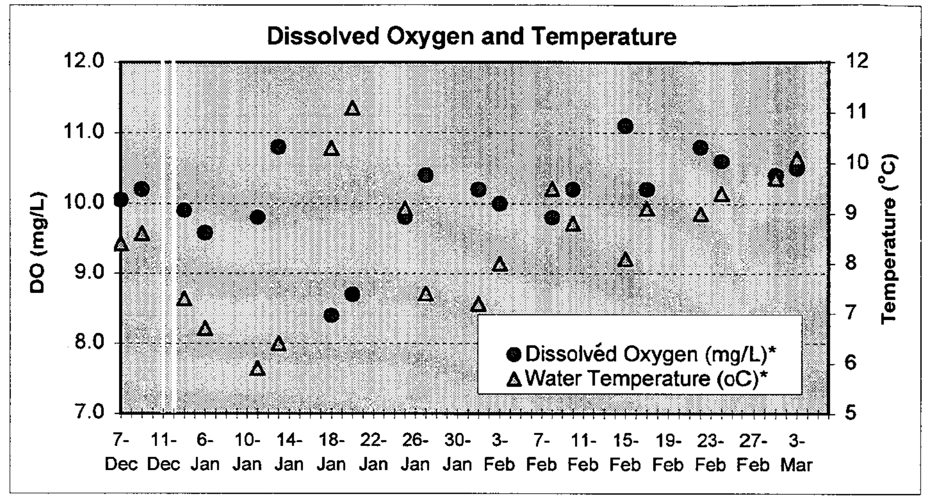


Figure 5. Environmental measurements for the Wadsworth Canal sites. Data was collected from the Butte House Road bridge on February 17 and 22, 1999. All other measurements were collected from the weir at South Butte Road. Ammonia levels are shown only when they exceed the detection limit of 50 µg/L. Double bar denotes a break in sampling between background and dormant season samples.
* Denotes measurements made on site.

ENVIRONMENTAL DATA FOR THE SUTTER BYPASS, WINTER 1998-99





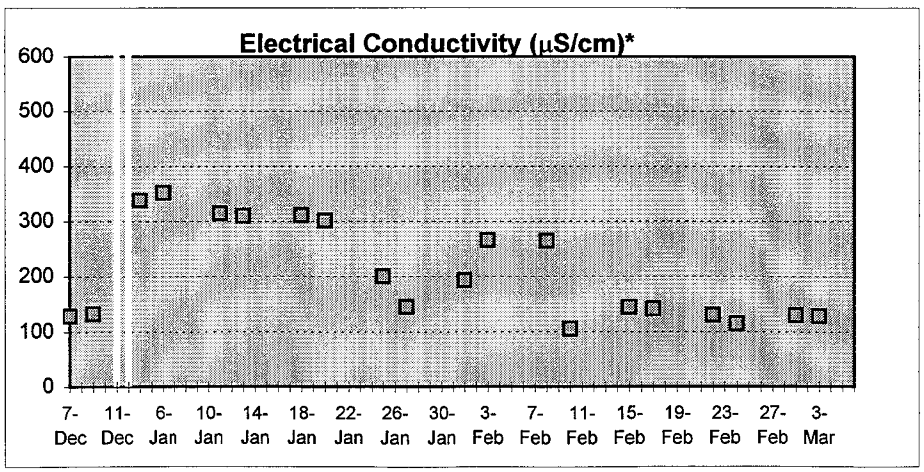


Figure 6. Environmental measurements for the Sutter Bypass taken either at the Karnak or the Kirkville Road sites. Data was collected at Karnak from January 4-18, 1999, all other measurements were made at Kirkville Road. Ammonia, alkalinity and hardness were not measured. Double bar denotes a break in sampling between background and dormant season samples. * Denotes measurements made on site.

ENVIRONMENTAL DATA FOR THE SACRAMENTO RIVER, WINTER 1998-99

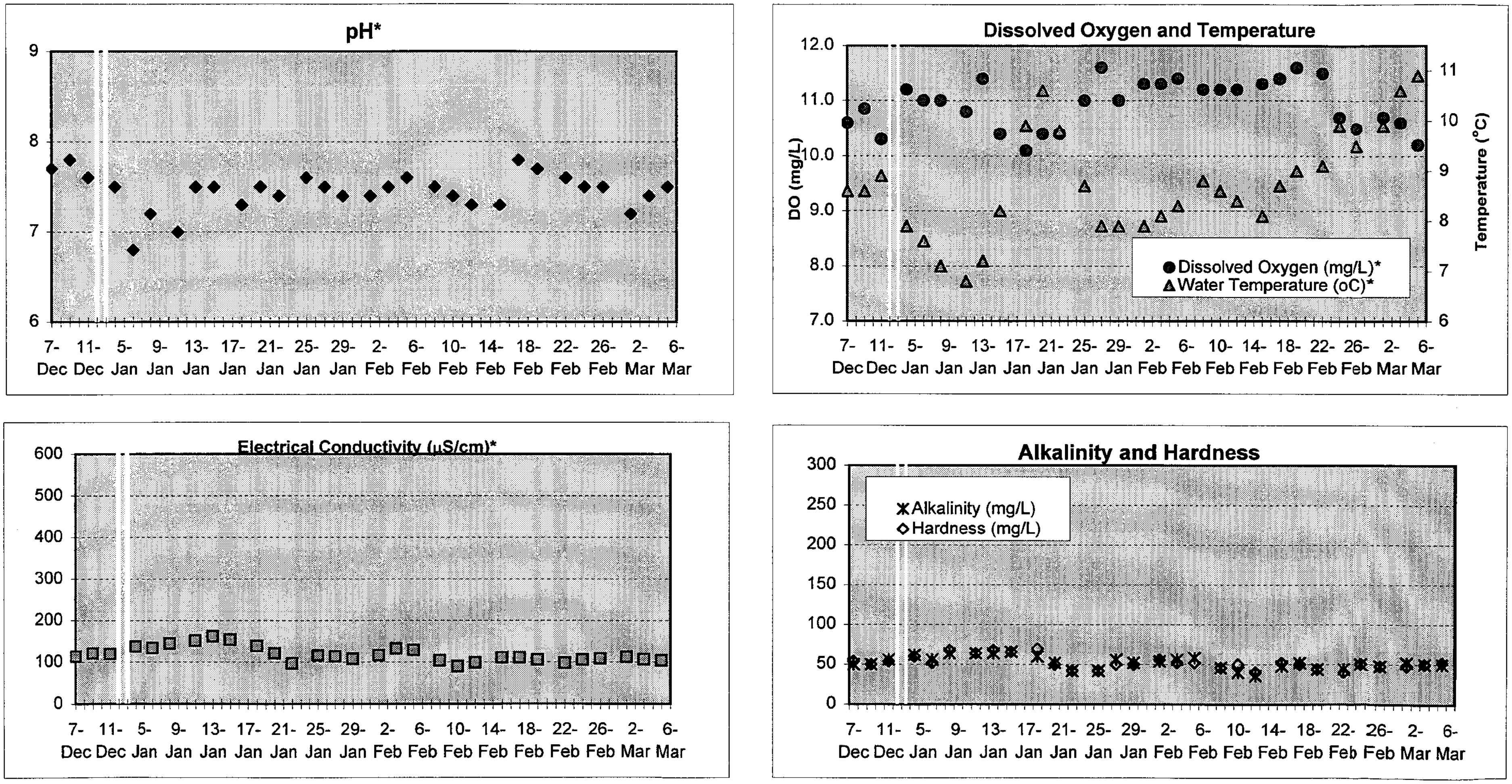


Figure 7. Environmental measurements for the Sacramento River at the Alamar Marina. Data collected from December 7-11, 1998 and January 4-March 5, 1999. Measurements were collected three times per week during the stated period. *Denotes measurements made on site. Double bar denotes a break in sampling between the background and dormant season samples.

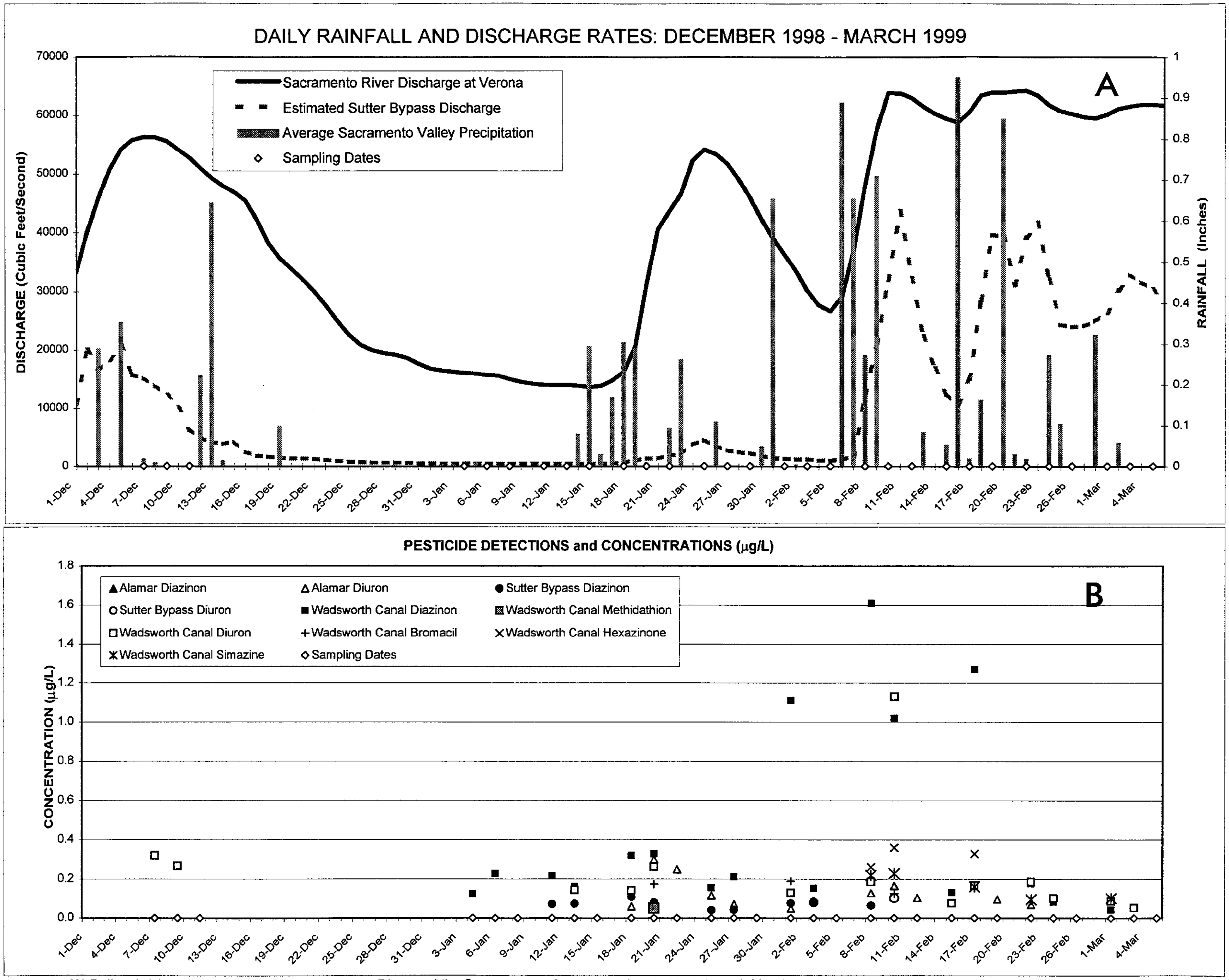


Figure 8. **(A)** Daily rainfall and discharge for the Sacramento River and the Sutter Bypass from December 1, 1998 through March 6, 1999. Rainfall data is an average of two stations in the Sacramento River Basin: Sacramento Post Office and Chico weather stations. Sacramento River discharge was measured at Verona. Sutter Bypass discharge was estimated by adding discharges from the Butte Slough near Meridian and Tisdale Bypass gages. Rainfall and discharge data is provisional and is subject to revision.
(B) Detected pesticide concentrations for the Sacramento River at Alamar, the Sutter Bypass and Wadsworth Canal for the period December 7-11, 1998 and January 4 through March 5, 1999. The Wadsworth Canal and Sutter Bypass sites were sampled twice per week and the Alamar site was sampled three times per week.

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